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The wind-induced bias of the Thies Laser Precipitation Monitor obtained using CFD and a Lagrangian particle tracking model

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Environmental sources of measurement biases affect the accuracy of non-catching (mostly contact-less) precipitation gauges (Lanza et al., 2021). Wind is among the most significant influencing variables, since instruments exposed to the wind generate strong airflow velocity gradients and turbulence near their sensing volume. Hydrometeor trajectories are diverted by the induced updraft/downdraft and acceleration near the instrument, affecting the measured particle size distribution, and leading to an over- or underestimation of the precipitation intensity. This bias is common to all precipitation measurement instruments, including traditional catching-type gauges, but is amplified in non-catching gauges due to their complex shapes and measuring principles. Wind also changes the velocity of the falling hydrometeors, introducing further potential biases since velocity is explicitly used by disdrometers (in combination with the hydrometeors size) to determine the type of precipitation and to discard outliers.

The present work focuses on the Thies laser precipitation monitor, which employs a laser beam to detect hydrometeors in fight. It has a complex, non-axisymmetric shape, due to the physical constraints of its measuring principle. To evaluate the effect of wind on liquid precipitation measurements, Computational Fluid Dynamics simulations were run, using OpenFOAM, together with a Lagrangian particle tracking model. The drag coefficient formulation validated by Cauteruccio et al. (2021) was implemented in the OpenFOAM package. Various drop diameters were considered (0.25, 0.5, 0.75 and from 1 to 8 mm in 1 mm increments), and for each drop size, the vertical and horizontal velocity components were set equal to the terminal velocity and the free-stream velocity, respectively. Nine angles of attack were considered, from 0° to 180°, in 22.5° increments. For each angle, five different wind speed values (2, 5, 10, 15 and 20 m/s) were simulated. Each combination was run twice, first using a constant velocity field (as if the instrument were transparent to the wind) to evaluate the sole shielding effect of the instrument body on the measurement section, and then using the effective velocity fields.

The data were then processed, using a suitable drop size distribution and for each velocity/angle/rainfall intensity combination the collection efficiency of the instrument was calculated. This work is funded as part of the activities of the EURAMET project 18NRM03 – "INCIPIT – Calibration and Accuracy of Non-Catching Instruments to measure liquid/solid atmospheric precipitation".

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